CONTROL UNIT AND METHOD FOR CONTROLLING MOTOR FOR USE IN PRINTER, AND STORAGE MEDIUM STORING CONTROL PROGRAM

BACKGROUND OF THE INVENTION

Field of The Invention

The present invention relates generally to a control unit and method for controlling a motor for use in a printer, and a storage medium storing a control program.

Description of Related Art

Conventionally, paper-feed control for printers is performed by controlling a paper-feed motor (called a PF motor hereinafter). Control of a PF motor using a DC(Direct Current) motor as the PF motor is performed as follows. The PF motor is started by acceleration control. The motor is then driven at a constant speed by PID control, and decelerated to stop. PID control is performed based on a deviation of the number of output pulses of an encoder that rotates to follow the rotation of the PF motor from a target number of pulses (position).

PID control is, however, has following drawbacks: It is difficult to precisely stop a PF motor at a target position. An actual position at which a PF motor stops may fall in an allowable range, however, is distant from the target position. The PF motor sometimes rotates a little bit after stoppage due to disturbance, such as, vibration of a carriage in serial printer.

In the event of paper-feed processing by starting a PF motor again after stoppage, since a target position for the motor is set with reference to the target position that has been set at a previous motor start-up before stoppage, printing medium (sheet of paper) may stop at a position further distant form the target position. This results in printing at positions distant from desired positions.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to eliminate the aforementioned problems and to provide a control unit, a method and also a storage medium storing a control program for controlling a motor for use in a printer, which offer precise positioning of a printing medium even the motor starts again after

stoppage.

The present invention provides A control unit for controlling a motor for use in a printer including: a position counter to count output pulses of an encoder that rotates to follow rotation of the motor and thereby detect a position of a printing medium transferred by the motor; a target control amount modifying and calculating part to calculate an modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and set a counted value of the position counter to the modified target value; and a position control part to control the motor so that the counted value of the position counter falls into a predetermined range including zero.

Moreover, the present invention provides a control unit for controlling a motor for use in a printer including: a position detecting part to detect a position of a printing medium transferred by the motor; a target position modifying and calculating part to calculate a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected by the position detecting part just before the present motor start-up; and a position control part to control the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

The target position modifying and calculating part may include: an error calculating part to calculate an error of the feed-amount of the printing medium at the previous motor start-up based on a target value of a control amount at a previous motor start-up and the position detected by the position detecting part just before the present motor start-up; and an adder to add the target value of a feed-amount of the printing medium at the present motor start-up and the error.

Furthermore, the present invention provides a control method of controlling a motor for use in a printer including the

steps of: counting output pulses of an encoder that rotates to follow rotation of the motor and detecting a position of a printing medium transferred by the motor by a position counter; calculating a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.

The step of controlling may perform PID control.

The position counter may count-up or count-down the output pulses according a normal or reverse rotation of the motor.

Moreover, the present invention provides a method of controlling a motor for use in a printer including the steps of: detecting a position of a printing medium transferred by the motor; calculating a modified target position value of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and controlling the motor based on positional deviation of the position detected by the position detecting part from the modified target position.

Furthermore, the present invention provides a processor readable medium storing program code for causing a computer to control a motor for use in a printer including: first program code means for, by a position counter, counting output pulses of an encoder that rotates to follow rotation of the motor to detect a position of a printing medium transferred by the motor; second program code means for modifying and calculating part to calculate a modified target value of a feed-amount of the printing medium based on a target value of a feed-amount of the printing medium and a previous stop position of the printing medium detected by the position counter, and setting a counted value of the position counter to the modified target value; and third program code means for controlling the motor so that the counted

value of the position counter falls into a predetermined range including zero.

Moreover, the present invention provides a processor readable medium storing program code for causing a computer to control a motor for use in a printer including: first program code means for detecting a position of a printing medium transferred by the motor; second program code means for calculating a modified target position of the printing medium based on a target value of a feed-amount of the printing medium at the present motor start-up, another target value of a feed-amount of the printing medium at a previous motor start-up, and a position of the printing medium detected just before the present motor start-up; and third program code means for controlling the motor based on positional deviation of the detected position of the printing medium from the modified target position.

Still furthermore, the present invention provides a control unit for controlling a motor for use in a printer including: a position counter to detect a position of a sheet of paper transferred by a paper-feed motor based on output pulses of an encoder that rotates to follow rotation of the paper-feed motor; a driving part to apply a current value to the paper-feed motor based on a target value of a feed-amount of the sheet of paper and an output of the position counter, to drive the paper-feed motor; a current value signal generating part to determine whether the absolute value of deviation of the output of the position counter from the target value of the feed-amount of the sheet of paper falls in the range of a first predetermined value to a second predetermined value smaller than the first predetermined value during stoppage of the paper-feed motor, to generate a current value signal, when the absolute value of deviation falls in the range, so that the deviation becomes zero, wherein the driving part drives the paper-feed motor based on the current value signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from

the detailed description given herebelow and from the accompanying drawings of the preferred embodiments of the invention. However, the drawings are not intended to imply limitation of the invention to a specific embodiment, but are for explanation and understanding only.

In the drawings:

FIG. 1 is a block diagram showing the construction of the first preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention;

FIG. 2 shows waveforms explaining the operation of the first preferred embodiment of a control unit for controlling a motor for use in a printer;

FIG. 3 is a block diagram showing the construction of the second preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention;

FIG. 4 is a block diagram showing an example of a target position modifying and calculating part according to the present invention;

FIG. 5 is a block diagram schematically showing the construction of an ink jet printer;

FIG. 6 is a perspective view showing the peripheral construction of a carriage;

FIG. 7 is a schematic view showing the construction of a linear type encoder;

FIGS. 8(a) and 8(b) are waveform illustrations of output pulses of an encoder;

FIG. 9 is a schematic perspective view of a printer for explaining the position of a paper detecting sensor;

FIG. 10 is a flow chart showing a control procedure in a method for controlling a motor for use in a printer according to the present invention;

FIG. 11 is a flow chart showing another control procedure in a method for controlling a motor for use in a printer according to the present invention;

FIG. 12 is a perspective view showing an example of a computer system using a storage medium, in which a print control program has been recorded, according to the present invention;

FIG. 13 is a block diagram showing an example of a computer system using a storage medium, in which a print control program has been recorded, according to the present invention;

FIG. 14 is a block diagram showing the construction of the seventh preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention;

FIG. 15 is a flow chart explaining the operation of the seventh preferred embodiment; and

FIG. 16 is a flow chart explaining the operation of a modification of the seventh preferred embodiment.

ODESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, the preferred embodiments of the present invention will be described below.

First, the schematic construction and control of an ink jet printer, which uses a control unit for controlling a motor for use in a printer according to the present invention, will be described. The schematic construction of this ink jet printer is shown in FIG. 5.

This ink jet printer comprises: a paper feed motor (which will be also hereinafter referred to as a PF motor) 1 for feeding a sheet of paper; a paper feed motor driver 2 for driving the paper feed motor 1; a carriage 3; a carriage motor (which will be also hereinafter referred to as a CR motor) 4; a CR motor driver 5 for driving the carriage motor 4; a DC unit 6; a pump motor 7 for controlling the suction of ink for preventing clogging; a pump motor driver 8 for driving the pump motor 7; a recording head 9, fixed to the carriage 3, for discharging ink to a printing paper 50; a head driver 10 for driving and controlling the recording head 9; a linear type encoder 11 fixed to the carriage 3; a code plate 12 which has slits in regular intervals; a rotary type encoder 13 for use in the PF motor 1; a paper detecting sensor 15 for detecting the position of the rear edge of a paper which is being printed; a CPU 16 for controlling the whole printer; a timer IC 17 for periodically generating an interruption signal to output the signal to the CPU 16; an interface part (which will be also hereinafter referred to as an IF) 19 for

transmitting/receiving data to/from a host computer 18; an ASIC 20 for controlling the printing definition, the driving waveform of the recording head 9 and so forth on the basis of printing information which is fed from the host computer 18 via the IF 19; a PROM 21, RAM 22 and EEPROM 23 which are used as working and program storing regions for the ASIC 20 and the CPU 16; a platen 25 for supporting the paper 50 during print; a carrier roller 27, driven by the PF motor 1, for carrying the printing paper 50; a pulley 30 mounted on the rotating shaft of the CR motor 4; and a timing belt 31 driven by the pulley 30.

Furthermore, the DC unit 6 is designed to drive and control the paper feed motor driver 2 and the CR motor driver 5 on the basis of a control command, which is fed from the CPU 16, and the outputs of the encoders 11 and 13. In addition, each of the paper feed motor 1 and the CR motor 4 comprises a DC motor.

The peripheral construction of the carriage 3 of this ink jet printer is shown in FIG. 6.

The carriage 3 is connected to the carriage motor 4 via the timing belt 31 and the pulley 30 to be driven so as to be guided by a guide member 32 to move in parallel to the platen 25. The carriage 3 is provided with the recording head 9 on the surface facing the printing paper. The recording head 9 comprises a nozzle row for discharging a black ink and a nozzle row for discharging color inks. Each nozzle is supplied with ink from an ink cartridge 34, and discharges drops of ink to the printing paper to print characters and/or images.

In a non-print region of the carriage 3, there are provided a capping unit 35 for sealing a nozzle opening of the recording head 9 during non-print, and a pump unit 36 having the pump motor 7 shown in FIG. 5. When the carriage 3 moves from a print region to the non-print region, the carriage 3 contacts a lever (not shown) to move the capping unit 35 upwards to seal the recording head 9.

When the nozzle opening row of the recording head 9 is clogged with ink, or when the cartridge 34 is exchanged or the like to force the recording head 9 to discharge ink, the pump unit 36 is operated in the sealed state of the recording head

9, to suck ink out of the nozzle opening row by a negative pressure from the pump unit 36. Thus, dust and paper powder adhering to a portion near the nozzle opening row are cleaned. Moreover, bubbles of the recording head 9, together with ink, are discharged to a cap 37.

Then, the construction of the linear type encoder 11 mounted on the carriage 3 is shown in FIG. 7. This encoder 11 comprises a light emitting diode 11a, a collimator lens 11b, and a detection processing part 11c. The detection processing part 11c has a plurality of (four) photodiodes 11d, a signal processing circuit 11e, and two comparators $11f_A$ and $11f_B$.

If a voltage Vcc is applied between both ends of the light emitting diode 11a via a resistor, light rays are emitted from the light emitting diode 11a. The light rays are collimated by the collimator lens 11b to pass through the code plate 12. The code plate 12 is provided with slits at regular intervals (e.g., every 1/180 inches (= 1/180 x 2.54 cm)).

The parallel rays passing through the code plate 12 are incident on each of the photodiodes 11d via a fixed slit (not shown), and converted into electric signals. The electric signals outputted from the four photodiodes 11d are processed by the signal processing circuit 11e. The signals outputted from the signal processing circuit 11e are compared by the comparators $11f_A$ and $11f_B$, and the compared results are outputted as pulses. The pulses ENC-A and ENC-B outputted from the comparators $11f_A$ and $11f_B$ are outputs of the encoder 11.

The phase of the pulse ENC-A is different from the phase of the pulse ENC-B by 90 degrees. The encoder 4 is designed so that the phase of the pulse ENC-A is advanced from the pulse ENC-B by 90 degrees as shown in FIG. 8(a) when the CR motor 4 is normally rotating, i.e., when the carriage 3 is moving a main scanning direction, and the phase of the pulse ENC-A lags behind the pulse ENC-B by 90 degrees as shown in FIG. 8(b) when the CR motor 4 is reversely rotating. One period T of the pulses corresponds to the distance between adjacent slits of the code plate 12 (e.g., 1/180 inches (= 1/180 x 2.54 cm)). This is equal to a period of time, in which the carriage 3 moves between the adjacent slits.

On the other hand, the rotary type encoder 13 for use in the PF motor 1 has the same construction as that of the linear type encoder 11, except that the code plate is a rotating disk which rotates in accordance with the rotation of the PF motor 1. Furthermore, in the ink jet printer, the distance between adjacent slits of a plurality of slits provided in the code plate of the encoder 13 for use in the PF motor is 1/180 inches (1/180 x 2.54 cm). When the PF motor 1 rotates by the distance between adjacent slits, the paper is fed by 1/1440 inches (= 1/1440 x 2.54 cm).

Referring to FIG. 9, the position of the paper detecting sensor 15 shown in FIG. 5 will be described below.

In FIG. 9, the paper 10 inserted into a paper feeding port 61 of a printer 60 is fed into the printer 60 by means of a paper feeding roller 64 which is driven by a paper feeding motor 63. The front edge of the paper 50, which has been fed into the printer 60, is detected by, e.g., an optical paper detecting sensor 15. The paper 50, the front edge of which has been detected by the paper detecting sensor 15, is fed by means of a paper feed roller 65 and a driven roller 66 which are driven by the PF motor 1.

Subsequently, ink drops from the recording head (not shown), which is fixed to the carriage 3 moving along the carriage guide member 32, to carry out a print. Then, when the paper is fed to a predetermined position, the rear edge of the paper 50, which is currently being printed, is detected by the paper detecting sensor 15. Then, a gear 67c is driven, via a gear 67b, by means of a gear 67a which is driven by the PF motor 1. Thus, a paper discharging roller 68 and a driven roller 69 are rotated to discharge the printed paper 50 from a paper discharging port 62 to the outside.

(First Preferred Embodiment)

The construction of the first preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention will be described below. Control of a motor use in a printer is performed by a DC unit 6 shown in FIG. 5 and its construction is shown in FIG. 1.

A control unit for controlling a motor for use in a printer

according to the present invention, that is, the DC unit 6 comprises a position counter 6a, a subtracter 6b, a target speed calculating part 6c, a speed calculating part 6d, a subtracter 6e, a proportional element 6f, an integrating element 6g, a differentiating element 6h, an adder 6i, a D/A converter 6j, a timer 6k, an acceleration control part 6m, and a feed-amount modifiying/calculating part 90.

The position counter 6a is designed to detect the leading and trailing edges of each of the output pulses ENC-A and ENC-B of the encoder 13 to count the number of the detected edges, and to calculate the rotary position of the PF motor 1 on the basis of the counted value. In this counting, when the PF motor 1 is normally rotating, if one edge is detected, "+1" is added, and when the PF motor 1 is reversely rotating, if one edge is detected, "-1" is added. Each of the periods of the pulses ENC-A and ENC-B is equal to the distance between adjacent slits of a code plate of the encoder 13, and the phase of the pulse ENC-A is different from the phase of the pulse ENC-B by 90 degrees. Therefore, the counted value "1" in the above described counting corresponds to 1/4 of the distance between adjacent slits of the code plate of the encoder 13. Thus, if the counted value is multiplied by 1/4 of the distance between adjacent slits, it is possible to obtain the moving amount of the PF motor 1 from a position corresponding to a counted value "0".

The feed-amount modifying/calculating part 90 operates based on a start-up command signal for starting the PF motor 1 fed from the CPU 16, to calculate a modified paper-feed amount based on a start-up target position "0" and the counted value (the number of pulses) of the position counter 6a just after receiving the start-up command signal, or a previous stop position. The modified paper-feed amount is fed to the position counter 6a for setting a counted value so that it corresponds to the modified paper-feed amount. The nearer to the target position, the smaller the counted value being set for the position counter 6a.

The subtracter 6b is designed to calculate a position deviation of the counted value of the position counter 6a, from

the target position "0".

The target speed calculating part 6c is designed to calculate a target speed of the PF motor 1 on the basis of the position deviation which is the output of the subtracter 6b. This operation is carried out by multiplying the position deviation by a gain K_p. This gain K_p is determined in accordance with the position deviation. Furthermore, the value of the gain K_p may be stored in a table (not shown).

The speed calculating part 6d is designed to calculate a speed of the PF motor 1 on the basis of the output pulses ENC-A and ENC-B of the encoder 13. This speed is obtained as follows. First, the leading and trailing edges of each of the output pulses ENC=A and ENC-B of the encoder 13 are detected, and the time interval between the edges is counted by, e.g., a timer counter. Assuming that the counted value is T, the speed of the PF motor 1 is proportional to 1/T. Furthermore, in this preferred embodiment, the speed of the PF motor is obtained by counting one period of the output pulse ENC-A, e.g., the period between the leading edge and the next leading edge, by means of a timer counter.

The subtracter 6e is designed to calculate a speed deviation of the actual speed of the PF motor 1, which is calculated by the speed calculating part 6d, from a target speed.

The proportional element 6f is designed to multiply the speed deviation by a constant Gp to output the multiplied result. The integrating element 6g is designed to integrate a value which is obtained by multiplying the speed deviation by a constant Gi. The differentiating element 6h is designed to multiply a difference between the current speed deviation and the last speed variation by a constant Gd to output the multiplied result. Furthermore, the operations in the proportional element 6f, integrating element 6g and differentiating element 6h are carried out every one period of the output pulse ENC-A of the encoder 13, i.e., in synchronism with the leading edge of the output pulse ENC-A.

The outputs of the proportional element 6f, integrating element 6g and differentiating element 6h are added by the adder

6i. Then, the added result, i.e., the driving current of the PF motor 1, is fed to the D/A converter 6j to be converted into an analog current. On the basis of the analog current, the PF motor 1 is driven by the paper-feed driver 2.

In addition, the timer 6k and the acceleration control part 6m are used for controlling acceleration, and the PID control using the proportional element 6f, integrating element 6g and differentiating element 6h is used for controlling the constant speed and deceleration during acceleration.

The timer 6k is designed to generate a timer interruption signal every a predetermined time on the basis of a clock signal which is fed from the CPU 16.

The acceleration control part 6m is designed to integrate a predetermined current value (e.g., 20 mA) into a target current value every time it receives the timer interruption signal, and to feed the integrated result, i.e., the target current value of the PF motor 1 during acceleration, to the D/A converter 6j. Similar to the PID control, the target current value is converted into an analog current by the D/A converter 6j. On the basis of this analog current, the PF motor 1 is driven by the driver 2.

The driver 2 has, e.g., four transistors. By turning each of the transistors ON and OFF on the basis of the output of the D/A converter 6j, the driver 2 can be selectively in (a) an operation mode in which the PF motor 1 is normally or reversely rotated, (b) a regenerative brake operation mode (a short brake operation mode, i.e., a mode in which the stopping of the PF motor 1 is maintained), or (c) a mode in which the PF motor 1 is intended to be stopped.

Referring to FIGS. 2(a) and 2(b), the operation of the DC unit 6, that is, the control unit for controlling a motor for use in a printer, will be described below.

If a start-up command signal for starting the PF motor 1 is fed from the CPU 16 to the DC unit 6 when the PF motor 1 is stopped,

a modified paper-feed amount is calculated by the feed-amount modifying/calculating part 90, and is set as a counted value of the position counter 6a, during which a start-up initial current

value I_0 is fed from the acceleration control part 6m to the D/A converter 6j. This start-up initial current value I_0, together with the start-up command signal, is fed from the CPU 16 to the acceleration control part 6m. Then, this current value I_0 is converted into an analog current by the D/A converter 6j to be fed to the driver 2, and the PF motor 1 is started up by the driver 2 (see FIG. 2(a), 2(b)).

After the start-up command signal is received, the timer 6k generates a timer interruption signal every a predetermined time. Every time the acceleration control part 6m receives the timer interruption signal, the acceleration control part 6m integrates a predetermined current value (e.g., 20 mA) into the start-up initial current value I_0, to feed the integrated current value to the D/A converter 6j. Then, the integrated current value is converted into an analog current by the D/A converter 6j to be fed to the driver 2. Then, the PF motor 1 is driven by the driver 2 so that the value of the current supplied to the PF motor 1 is the integrated current value, so that the speed of the PF motor 1 increases (see FIG. 2(b)). Therefore, the current value supplied to the PF motor 1 is step-wise as shown in FIG. 2(a).

Furthermore, at this time, although the PID control system also operates, the D/A converter 6j selects and incorporates the output of the acceleration control part 6m.

The integration of the current value in the acceleration control part 6m is carried out until the integrated current value becomes a constant current value I_s. When the integrated current value becomes the predetermined value I_s at time t_1, the acceleration control part 6m stops the integration, and supplies the constant current value I_s to the D/A converter 6j. Thus, the PF motor 1 is driven by the driver 2 so that the value of the current supplied to the PF motor 1 becomes the current value I_s (see FIG. 2(a)).

Then, in order to prevent the speed of the PF motor 1 from overshooting, the acceleration control part 6m controls the PF motor 1 so as to reduce the current, which is supplied to the PF motor 1, when the speed of the PF motor 1 becomes a predetermined speed V_1 (see time t_2). At this time, the speed of the PF motor

1 further increases. However, when the speed of the PF motor 1 reaches a predetermined speed V_c (see time t_3 in FIG. 2(b)), the D/A converter 6j selects the output of the PID control system, i.e., the output of the adder 6i, to carry out the PID control.

That is, the target speed is calculated on the basis of the position deviation of the counted value of the counter 6a from the target position "0". In addition, the proportional element 6f, integrating element 6g and differentiating element 6h are operated on the basis of the speed deviation of the actual speed, which is obtained from the output of the encoder 13, from the target speed to carry out the proportional, integrating and differentiating operations. Moreover, the PF motor 1 is controlled on the basis of the sum of these calculated results. Furthermore, the above described proportional, integrating and differentiating operations are carried out in synchronism with, e.g., the leading edge of the output pulse ENC-A of the encoder 13. Thus, the speed of the PF motor 1 is controlled so as to be a desired speed V_e. Furthermore, the predetermined speed V_c is preferably a value of 70 % to 80 % of the desired speed V_e.

The speed of the PF motor 1 reaches the desired speed V_e after time t_4. When the PF motor 1 reaches the target position (see time t_5 in FIG. 2(b)), the PF motor 1 is decelerated to be stopped at time t_6.

As disclosed above, according to the present invention, a paper-feed amount at the present start-up is modified by the feed-amount modifying/calculating part 90 based on the present target feed-amount and the counted value of the position counter 6a just after receiving a start-up command signal, or a previous stop position, the modified paper-feed amount being set as a counted value of the position counter 6a for paper-feed control based on the deviation of the output of the position counter 6a and the target value "0".

The paper-feed control according to the present invention thus offers precise paper feeding so that a sheet of paper is stopped at a target position. The target value is not only "0", but preferably falls in the range from -3 to +3 including "0".

The maximum counted value of the position counter 6a

corresponds to a modified paper-feed amount in this embodiment, thus requiring a small capacity for the position counter 6a.

(Second Preferred Embodiment)

The construction of the second preferred embodiment of a control unit for controlling a motor for use in a printer according to the present invention will be described below.

Control of a motor for use in a printer according to this embodiment is performed by a DC unit 6 shown in FIG. 5 the construction of which is shown in FIG. 3.

The control unit for controlling a motor for use in a printer according to this embodiment, that is, the DC unit 6 corresponds to the control unit for controlling a motor for use in a printer according to the first embodiment, but having a target position modifying/calculation part 80.

The target position modifying/calculation part 80 operates based on a start-up command signal for starting the PF motor 1 fed from the CPU 16, to calculate a modified target position based on a target feed-amount (the number of pulses) at a previous PF motor start-up, a target feed-amount (the target number of pulses) at the present PF motor start-up, and the counted value (the number of pulses) of the position counter 6a just after receiving the start-up command signal. The calculation result is fed to the subtracter 6b.

An example of the construction of the target position modifying/calculation part 80 is shown in FIG. 4.

The target position modifying/calculation part 80 is provided with a memory 81, an error calculating part 82, an adder 83 and a reset signal generating part 84.

The memory 81 feeds the stored target feed-amount at a previous PF motor start-up to the error calculating part 82 based on the start-up command signal, and stores the target feed-amount at the present PF motor start-up fed from the CPU 16, in place of the target feed-amount that has been stored.

The error calculating part 82 calculates an error, that is, the difference between the target feed-amount at the previous PF motor start-up fed from the memory 81 and the counted value (the number of pulses) of the counter 6a just after receiving

the start-up command signal. The error is fed to the adder 83 and also to the reset signal generating part 84 that generates a reset signal for resetting the start-up command. The error is a positive or negative value.

The adder 83 adds the error and the target position (target feed-amount) at the present PF motor start-up fed from the CPU 16, to generate the addition result as a target position.

The reset signal generating part 84 that generates a reset signal to reset the counted value of the position counter 6a to "0". The reset signal generating part 84 may generate a reset signal based on the output of the adder 83 instead of a command signal from the error calculating part 82.

The subtracter 6b calculates the positional deviation of an actual position of the PF motor 1 calculated by the position counter 6a from a modified target position fed by the target position modifying/calculation part 80. Paper-feed control is performed like the first embodiment so that the deviation becomes zero.

As disclosed, according to this embodiment, the target position modifying/calculation part 80 modifies the target position at the present PF motor start-up based on the target position and the counted value of the position counter 6a just after receiving the start-up command signal for paper-feed control based on the positional deviation of the output of the position counter 6a from the modified target value, thus achieving precise paper feeding.

The first and the second embodiments are disclosed as applied to an ink jet printer, however, can be applied to other printers, such as, a serial printer and a laser printer. Moreover, the first and the second embodiments are disclosed using a DC motor, however, can use an AC motor. Furthermore, the first and the second embodiments are disclosed using a sheet of paper as a printing medium, however, can use other printing media.

(Third Preferred Embodiment)

The third preferred embodiment according to the present invention will be described with reference to FIG. 10. The third embodiment is a method of controlling a motor for use in a printer

the control procedure of which is shown in FIG. 10.

Output pulses of an encoder that rotates to follow the rotation of a PF motor are counted by a position counter to detect a position of a printing medium (a sheet of paper) transferred by the PF motor (see step F10 in FIG. 10). Calculated next is an modified target feed-amount based on a target printing medium-feed amount and a previous stop position of the printing medium detected by the position counter, the modified target feed-amount being set to a counted value of the position counter (see step F11 in FIG. 10). The PF motor is then controlled so that the counted value of the position counter falls into a predetermined range including zero (see step F12 in FIG. 10).

The control method as disclosed above is capable of stopping a printing medium at a target position, thus achieving precise paper feeding.

(Fourth Preferred Embodiment)

The fourth preferred embodiment according to the present invention will be described with reference to FIG. 11. The fourth embodiment is a method of controlling a motor for use in a printer the control procedure of which is shown in FIG. 11.

A position of a printing medium (a sheet of paper) transferred by a PF motor is detected (see step F20 in FIG. 11). Calculated next is a modified target position of the printing medium based on a target printing medium feed-amount at the present PF motor start-up, a target printing medium feed-amount at a previous PF motor start-up, and a detected position of the printing medium just before the present PF motor start-up (see step F21 in FIG. 11). The PF motor is then controlled based on the deviation of the detected position of the printing medium from the modified target position (see step F21 in FIG. 11).

The control method as disclosed above thus achieves precise paper feeding.

The step of calculating a modified target position may further includes the step of calculating an error of the printing medium feed-amount after the previous PF motor start-up based on the target printing medium-feed amount at the previous PF motor start-up and the detected position of the printing medium just

before the present PF motor start-up, and the step of calculating the modified target position by adding the target printing medium feed-amount at the present motor start-up and the error.

(Fifth Preferred Embodiment)

Referring to FIGS. 12 and 13, the fifth preferred embodiment of the present invention will be described below. This preferred embodiment relates to a storage medium, in which a control program for controlling a motor for use in a printer has been stored. FIGS. 12 and 13 are a perspective view and block diagram showing an example of a computer system 130 which uses a storage medium, in which a print control program in this preferred embodiment has been recorded.

In FIG. 12, the computer system 130 comprises a computer body 130 including a CPU, a display unit 132, such as a CRT, an input unit 133, such as a keyboard or mouse, and a printer 134 for carrying out a print.

As shown in FIG. 13, the computer body 131 comprises an internal memory 135 of a RAM, and a built-in or exterior memory unit 136. As the memory unit 136, a flexible or floppy disk (FD) drive 137, a CD-ROM drive 138 and a hard disk drive (HD) unit 139 are mounted. As shown in FIG. 12, a flexible disk or floppy disk (FD) 141 which is inserted into a slot of the FD drive 137 to be used, a CD-ROM 142 which is used for the CD-ROM drive 138, or the like is used as a storage medium 140 for use in the memory unit 136.

As shown in FIGS. 12 and 13, it is considered that the FD 141 or the CD-ROM 142 is used as the storage medium for use in a typical computer system. However, since this preferred embodiment relates to a control program for controlling a motor for use in the printer 134, the control program of the present invention may be recorded in, e.g., a ROM chip 143 serving as a nonvolatile memory which is built in the printer 134. Of course, the storage medium may be any one of FDs, CD-ROMs, MOs (Magneto-Optical) disks, DVDs (Digital Versatile Disks), other optical recording disks, card memories, and magnetic tapes.

The storage medium 140 in this preferred embodiment is designed to carry out a control procedure including steps F10

through F12 shown in FIG. 10. That is, the storage medium 140 in this preferred embodiment may carry out the steps of, at least, detecting a position of a printing medium transferred by a motor by a position counter by counting output pulses of an encoder that rotates to follow the rotation of the motor, calculating a modified target feed-amount value based on a target printing medium feed-amount and a previous stop position of the printing medium detected by the position counter, and setting an counted value of the position counter to the modified target value, and controlling the motor so that the counted value of the position counter falls into a predetermined range including zero.

(Sixth Preferred Embodiment)

The sixth preferred embodiment of the present invention will be described below. This preferred embodiment relates to a storage medium, in which a control program for controlling a motor for use in a printer has been stored. The control program includes the steps of F20 to F22 shown in FIG. 11.

The storage medium according to this embodiment may store, at least, the program code of detecting a position of a printing medium transferred by a motor, the program code of calculating a modified target position of the printing medium based on a target feed-amount value of the printing medium at the present motor start-up, a target feed-amount value of the printing medium at a previous motor start-up, and a detected position of the printing medium just before the previous motor start-up, and the program code of controlling the motor based on the deviation of the detected position of the printing medium from the modified target position.

The program code of calculating the modified target position of the printing medium may at least includes the step of calculating an error of the feed-amount after the previous motor start-up based on the target feed-amount value at the previous motor start-up and the detected valued of the printing medium just before the present motor start-up, and the step of calculating the modified target position by adding the target feed-amount value at the present motor start-up and the error.

As disclosed, the present invention achieves precise

stoppage of a printing medium even a motor for transferring the printing medium is started again after stoppage.

(Seventh Preferred Embodiment)

The control unit for controlling a motor for use in a printer according to the first embodiment offers precise paper feeding. However, this embodiment has a drawback in that printing at an accurate position would not be expected, when the original position "0" of the paper 50 varies, for example, caused by pulling the paper by a user, after stoppage even though no paper feed-command (start-up command) is received.

Such a problem is overcome by the seventh embodiment which will be disclosed below.

The seventh embodiment is disclosed with reference to FIGS. 14 and 15. FIG. 14 shows a block diagram of a control unit for controlling a motor for use in a printer according to this embodiment. FIG. 15 shows a flow chart explaining the operation of the control unit according to this embodiment.

The difference between the control units 6 according to the first and the seventh embodiments are that the latter unit includes a current value signal generating part 6p and a paper delivery processing part 6q. The other parts are the same between the two embodiments, and the explanation of those is omitted here because they have been explained in the first embodiment.

The current value signal generating part 6p determines whether the absolute value of the positional deviation output by the subtracter 6b falls in the range from a predetermined value N_1 and another predetermined value N_2 ($< N_1$) while the PF motor 1 is being stopped. If the absolute value falls in the range, the current value signal generating part 6p generates a current value signal that resets the deviation to "0". The current value signal is fed to the D/A converter 6j. On the other hand, paper delivery processing is performed if the absolute value is larger than the predetermined value N_1. Or, the control processing ends if the absolute value is equal to or smaller than the predetermined value N_2.

The paper delivery processing part 6q feeds a current values signal required for paper delivery to the D/A converter 6j when

it receives a paper delivery command from the current value signal generating part 6p.

The predetermined value N_2 is set, for example, to 1/1440 inches (= 1/1440 x 2. 54 cm), that is, the value corresponding to one cycle of the output pulse ENC-A of the encoder 13. In general, a motor for use in a printer stops within a range of positional deviation ± 11/5760 inches (= 11/5760 x 2. 54 cm) because it is difficult to stop the motor at a position where the positional deviation is zero. The value N_2 in this embodiment is set to the value smaller than the positional deviation in general.

On the other hand, the predetermined value N_1 is set, for example, to 22/1440 inches (= 22/1440 x 2. 54 cm). This is because paper feeding in the direction that is the reverse of a paper delivery direction would cause lifting-up of a locking lever of a carriage connected to a paper-feed motor so that the carriage would collide with the locking lever when flashing or capping, and also cause jamming of sheets of paper that have been released from a paper feeder and transferred in the reverse direction with no places to be transferred, thus there is a limit for paper feeding in the reverse direction.

The predetermined values N_1 and N_2 can be varied according to the type of sheets of paper (thickness and surface friction coefficient, etc.) and the number of usage.

The operation of the current value signal generating part 6p is disclosed with reference to FIG. 15.

Assumption is made that the PF motor 1 stops after starting-up.

The current value signal generating part 6p determines whether the absolute value of the positional deviation output by the subtracter 6b is equal to or smaller than the predetermined value N_1 (see step F1 in FIG. 15). The current value signal generating part 6p feeds a paper delivery command to the paper delivery processing part 6q if the absolute is larger than the predetermined value N_1. The paper delivery processing part 6q then feeds a current value signal required for paper delivery to the D/A converter 6j to start the PF motor 1 for paper delivery

processing based on the current value signal (see step F2 in FIG. 15).

On the other hand, if the absolute of the positional deviation is equal to or smaller than the predetermined value N_1, the current value signal generating part 6p further determines whether the absolute value is equal to or smaller than the predetermined value N_2 (see step F3 in FIG. 15). If so, the processing ends; while if not, or the absolute value is larger than the predetermined value N_2, the current value signal generating part 6p feeds a current value signal to the D/A converter 6j so that the positional deviation becomes zero (see step F4 in FIG. 15). The PF motor 1 then starts based on the current values signal and is controlled so that the positional deviation becomes zero (see step F5 in FIG. 15).

According to this control method, the original position for printing returns to the position before deviation, thus achieving printing at accurate positions.

The current value signal generating part 6p operates based on the output of the subtracter 6b in this embodiment, however, it may operates based on the output of the position counter 6a.

Moreover, the paper delivery processing is performed in this embodiment when the absolute value of the positional deviation is larger than the predetermined value N_1, however, printing can be performed with a deviated position as the original position with no paper delivery processing.

Furthermore, the absolute value of the positional deviation is firstly compared with the predetermined value N_1 and then compared with the predetermined value N_2, however, it can be compared with the predetermined value N_2 firstly and then compared with the predetermined value N_1, as indicated by the flow chart shown in FIG. 16. The steps F1 and F3 in FIG. 15 are reversed in FIG. 16.

As disclosed above, according to this embodiment, the original position for printing can be returned to the original even if deviated after the PF motor stops, thus achieving continuous printing at accurate positions. This embodiment also has the same advantages for the first embodiment.

Moreover, this embodiment has been disclosed using a DC motor as the PF motor 1, however, can use an AC motor with the same advantages.

(Eighth Preferred Embodiment)

The eighth preferred embodiment of the present invention will be described below. This preferred embodiment relates to a storage medium, in which a control program for controlling a motor for use in a printer has been stored. The control program includes the steps of F1 to F5 shown in FIG. 15 or 16.

The storage medium according to this embodiment may store, at least, the program code of obtaining the deviation of an actual feed-amount of a sheet of paper calculated based on output pulses of an encoder that rotates to follow the rotation of a paper-feed motor from a target paper feed-amount value at a previous motor start-up while motor is stopping, the program code of determining whether the absolute value of the deviation falls in a range between a first predetermined value and a second predetermined value smaller than the first predetermined value, the program code of generating a current value signal so that the deviation becomes zero when the absolute value of the deviation is judged as falling in the range, and the program code of controlling the motor based on the current value signal.

While the present invention has been disclosed in terms of the preferred embodiment in order to facilitate better understanding thereof, it should be appreciated that the invention can be embodied in various ways without departing from the principle of the invention. Therefore, the invention should be understood to include all possible embodiments and modification to the shown embodiments which can be embodied without departing from the principle of the invention as set forth in the appended claims.